Building Confidence with Validation at JPL

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Overview

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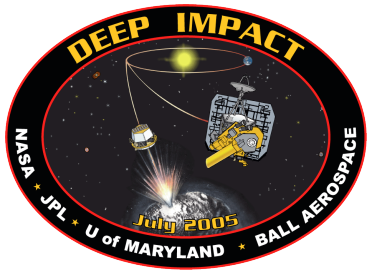
Background

- NASA was one of PRICE Systems' first customers in 1975
  - We have teamed up on many calibration and validation studies over the years
- PRICE provides a tool called TruePlanning, which is a platform for many predictive cost models, including the PRICE Hardware, Systems and Software Catalogs used for this validation project
- In the last few years the PRICE Cost Research Team has added hundreds of Space data points for estimating projects such as this
  - Over 1700 Structure/Electronics calibrations added to the Equipment Type Wizard, including "Unmanned Space-Planetary" and "Unmanned Space-Earth Orbiting" Operating Environments

Overview

- The main goal was to establish a consistent methodology for using TruePlanning to estimate JPL flight projects
- The team initially selected five projects to validate, and then expanded the study to include a total of ten JPL flight projects

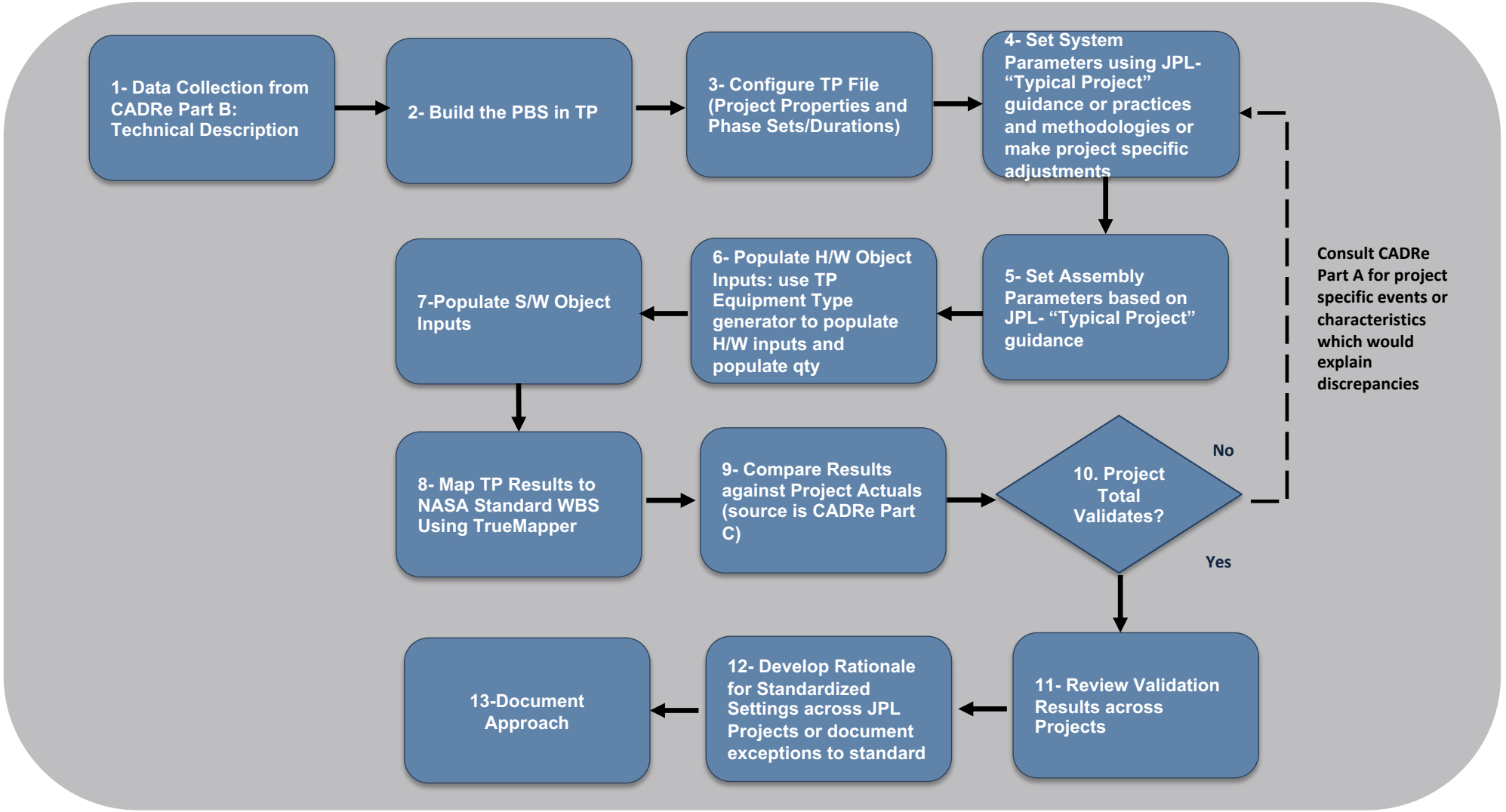


Goals

Six objectives:

- Validate TruePlanning 2016 against actual costs
- Establish a repeatable process for estimating JPL flight project costs in TruePlanning
- Provide recommended mapping for System and Assembly costs objects to NASA Standard WBS
- Document results and communicate to end-users
- Standardize guidance to ensure application of the tool is consistent across JPL flight projects
- Provide guidance to external entities when model is used for assessing JPL flight projects

Validation Process



Missions Validated

Mission	In-House or Subcontracted S/C	Deep Space	Mission Target Body	Number of Instruments	Mission Risk Class	Mission AO/Directed
Dawn	Subcontracted	Yes	Comet	3	B	AO
Deep Impact	Subcontracted	Yes	Comet	2	B	AO
GRAIL	Subcontracted	No	Moon	2	B	AO
Juno	Subcontracted	Yes	Jupiter	8	B	AO
Kepler	Subcontracted	No	Earth-Trailing	1	B	AO
MRO	Subcontracted	Yes	Mars	7	B	Directed
MSL	In-House	Yes	Mars	11	B	Directed
NuSTAR	Subcontracted	No	Low Earth Orbit	1	D	AO
SMAP	In-House	No	Earth Observing	1	C	Directed
WISE	Subcontracted	No	Sun Synchronous	1	C	AO

Source of Data

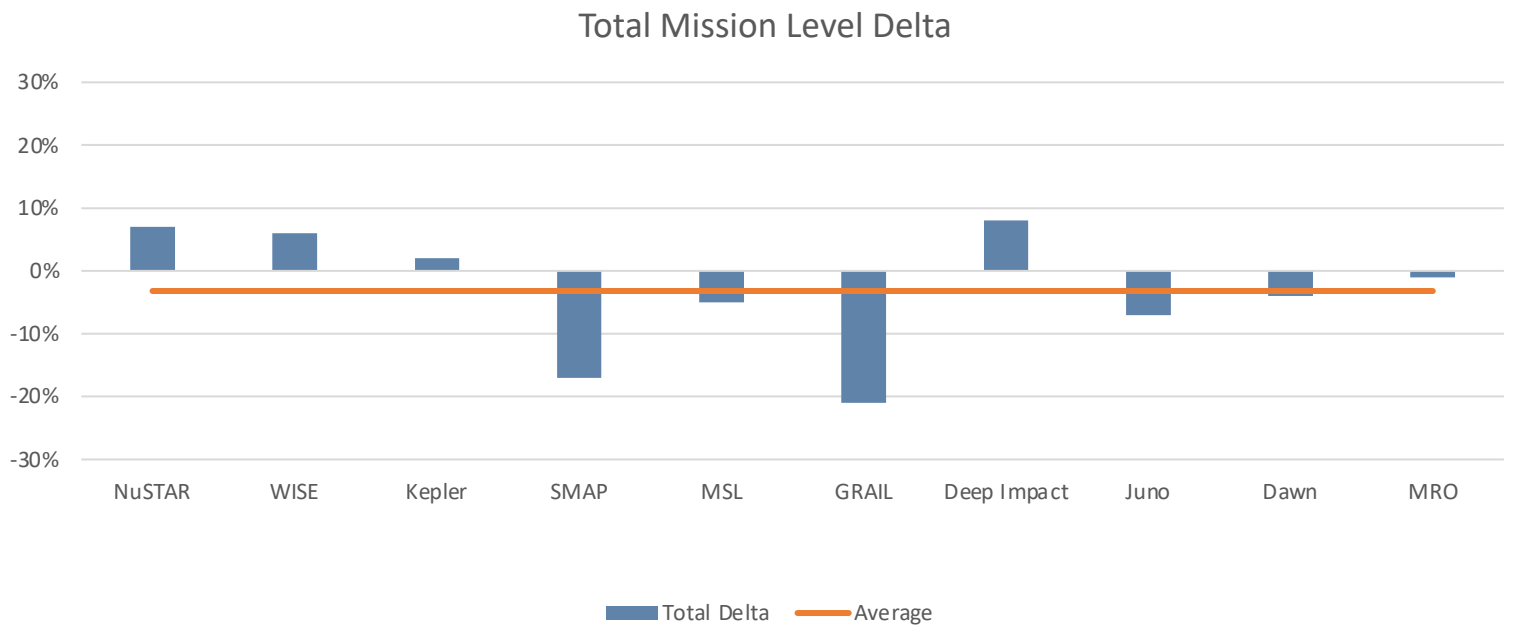
- Primary source was Cost Analysis Data Requirements (CADRe)
- CADRe Part C was used as source of cost data and schedule
- Missions modeled in TruePlanning to the CADRe Part B technical description
- CADRe Part A was consulted for further fine tuning
- Utilized TruePlanning Hardware Catalogue and Equipment Type Calculators

Validation Criteria

- The criteria for successful validation was for each project to model within 30% of actuals
- 30% represents percentage attributed to model uncertainty experienced at the early formulation stage
- This model uncertainty is in line with the average growth experienced by projects during development
- Deltas between TruePlanning and project actuals are as follows:

$$Delta\ \% = \frac{(\text{TruePlanning Output Cost} - \text{Project Cost Actuals})}{\text{Project Cost Actuals}} \times 100$$

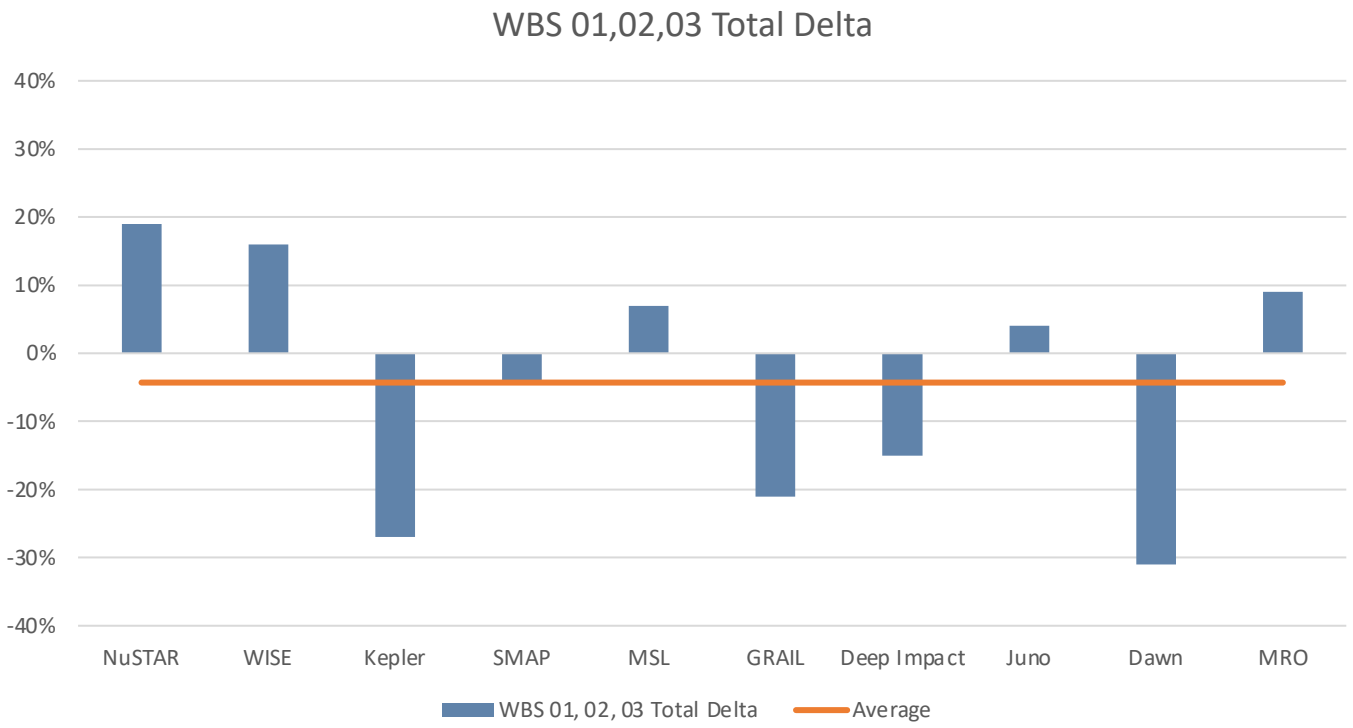
Study Results: Mission Level



Mission	Total Delta
NuSTAR	7%
WISE	6%
Kepler	2%
SMAP	-17%
MSL	-5%
GRAIL	-21%
Deep Impact	8%
Juno	-7%
Dawn	-4%
MRO	-1%

Average %	-3%

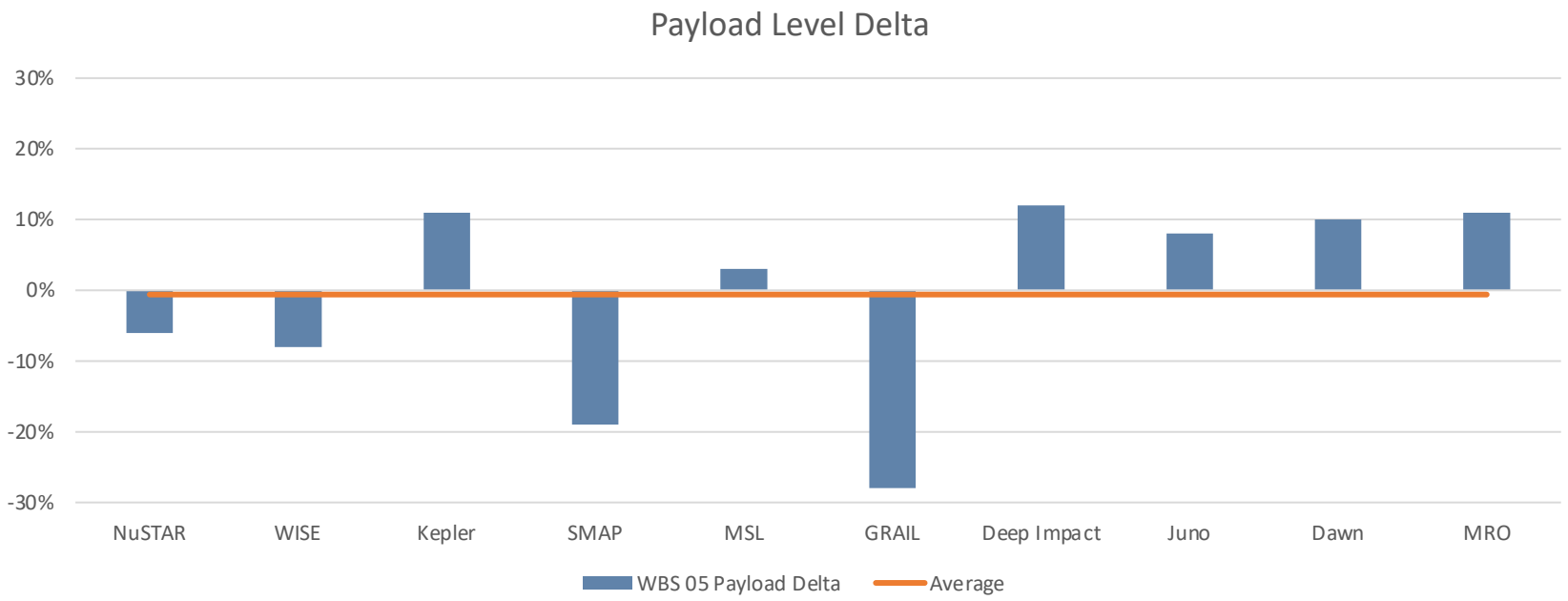
WBS 01, 02, 03



Mission	WBS 01, 02, 03 Total Delta
NuSTAR	19%
WISE	16%
Kepler	-27%
SMAP	-4%
MSL	7%
GRAIL	-21%
Deep Impact	-15%
Juno	4%
Dawn	-31%
MRO	9%

Average %	-4%

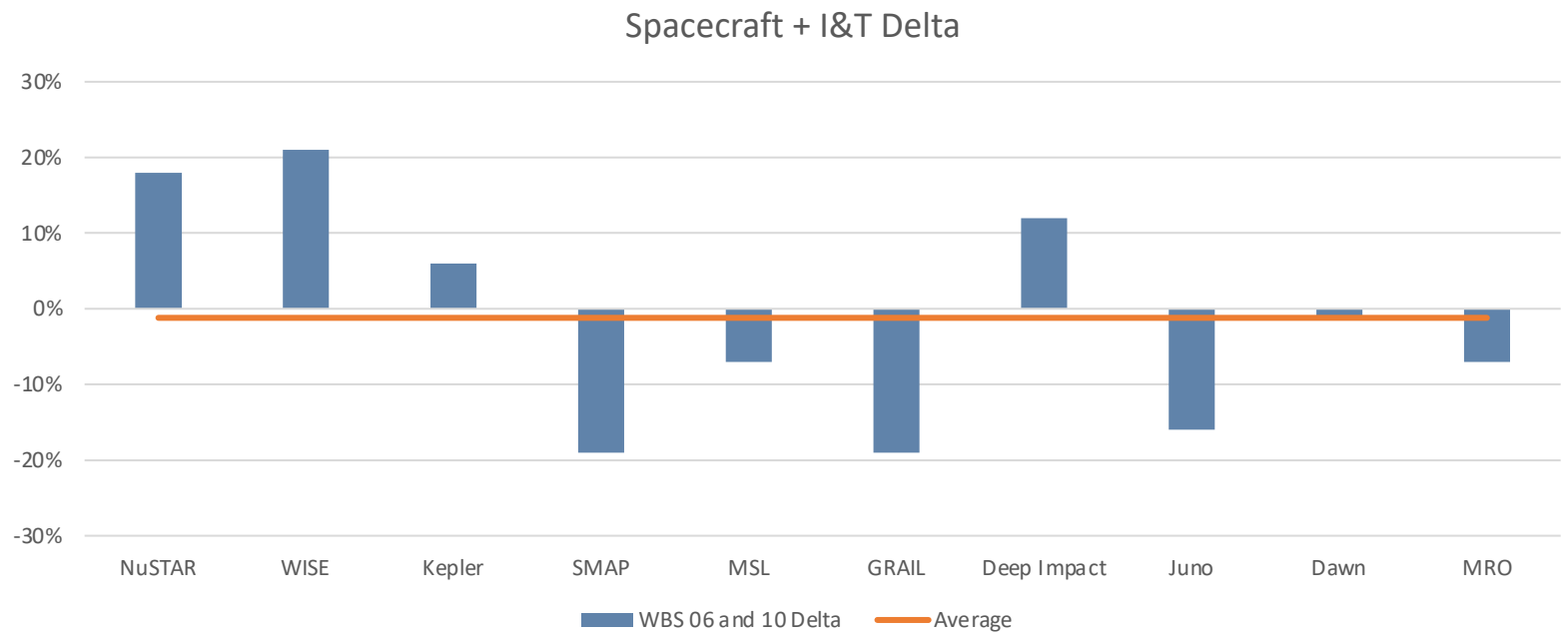
WBS 05 Payload



Mission	WBS 05 Payload Delta
NuSTAR	-6%
WISE	-8%
Kepler	11%
SMAP	-19%
MSL	3%
GRAIL	-28%
Deep Impact	12%
Juno	8%
Dawn	10%
MRO	11%

Average %	-1%

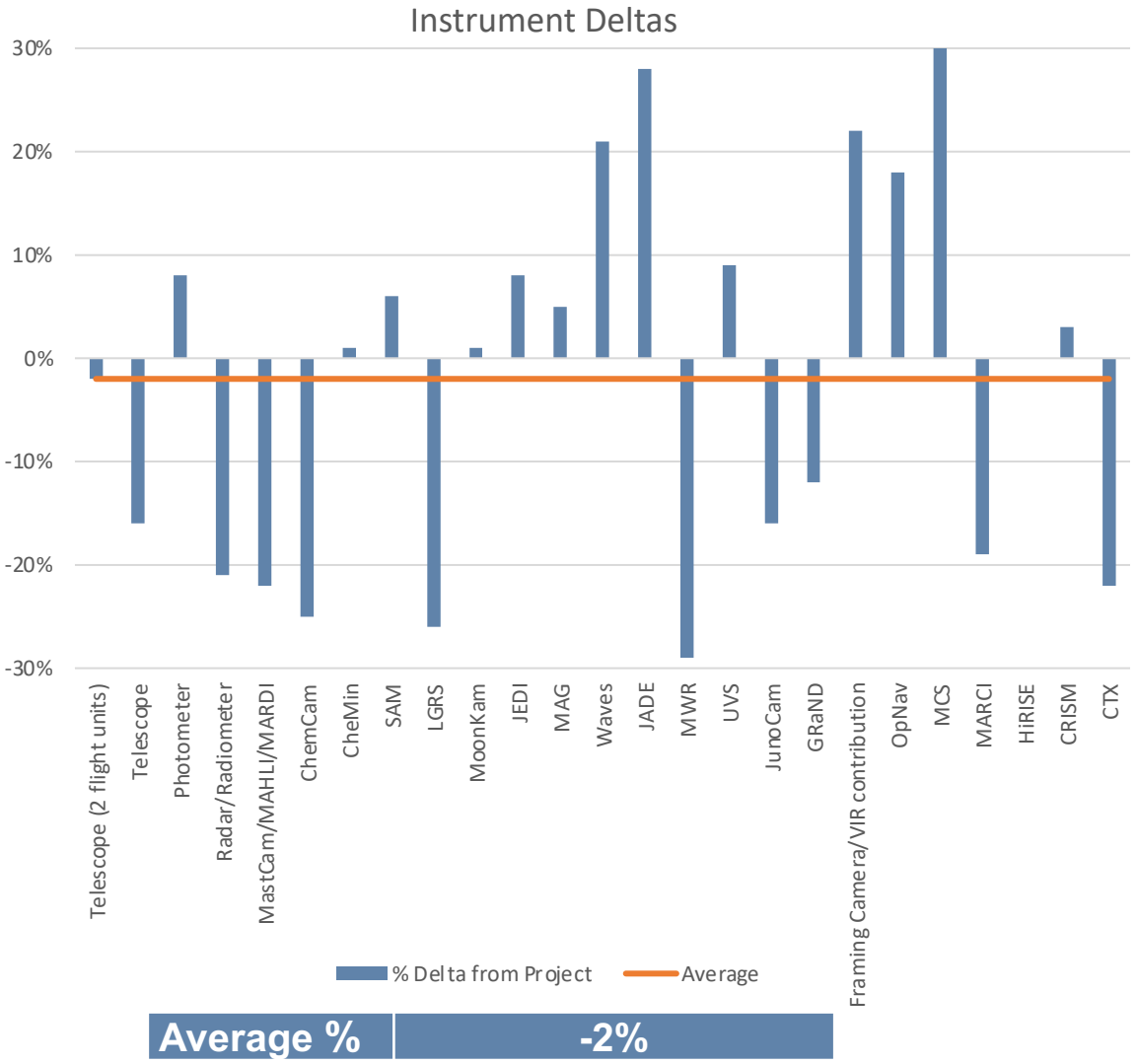
WBS 06 + 10 Spacecraft and Project I&T



Mission	WBS 06 and 10 Delta
NuSTAR	18%
WISE	21%
Kepler	6%
SMAP	-19%
MSL	-7%
GRAIL	-19%
Deep Impact	12%
Juno	-16%
Dawn	-1%
MRO	-7%

Average %	-1%

Instruments



Average %	-2%

Mission	Validated Instruments	% Delta from Project
NuSTAR	Telescope (2 flight units)	-2%
WISE	Telescope	-16%
Kepler	Photometer	8%
SMAP	Radar/Radiometer	-21%
MSL	MastCam/MAHLI/MARDI	-22%
MSL	ChemCam	-25%
MSL	CheMin	1%
MSL	SAM	6%
GRAIL	LGRS	-26%
GRAIL	MoonKam	1%
Juno	JEDI	8%
Juno	MAG	5%
Juno	Waves	21%
Juno	JADE	28%
Juno	MWR	-29%
Juno	UVS	9%
Juno	JunoCam	-16%
Dawn	GRaND	-12%
Dawn	Framing Camera/VIR contribution	22%
MRO	OpNav	18%
MRO	MCS	30%
MRO	MARCI	-19%
MRO	HiRISE	0%
MRO	CRISM	3%
MRO	CTX	-22%

Conclusion

- The study established a repeatable process for estimating JPL flight projects in TruePlanning
- Results are consistent with the levels of uncertainty seen in proposals and the early formulation work
- Project Level Specific Adjustments to System and Assembly Cost Objects should be used to capture differences in project complexity or implementation approach in order to provide a representative estimate for a new project with such variations.
- In the future, additional data points can be added to the study, to expand the scope of the validation.

Acronyms

CADRe	Cost Analysis Data Requirements
H/W	Hardware
PBS	Product Breakdown Structure
QTY	Quantity
S/C	Spacecraft
S/W	Software
TP	TruePlanning
WBS	Work Breakdown Structure

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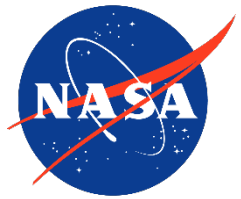

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